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TI: Electromagnetic switching device for valve actuated by coil has magnetic flux sensor connected to core detecting variable proportional to flux in core, and power supplied to coil controlled in accordance with detected flux

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AB: The actuator for a valve has an armature (2) which is displaced into a valve closure position when a coil (4) is energised. To reduce the electrical power loss and to increase the operational reliability of the actuator, a magnetic flux sensor (3) for detecting a variable proportional to the magnetic flux is connected to the core (1). The magnetic fluid sensor (3) is connected to an electronic controller (5) in such a manner that the electrical power supplied to the coil (4) can be controlled by the detected variable proportional to the magnetic flux. The sensor may be a Hall effect device or a magnetic field variable resistor connected in a bridge circuit. \$; Controlling liquid or gaseous media or hydraulic fluid, switched states are maintained safely, reduces power consumption in switched state, reduces working or operating temps.

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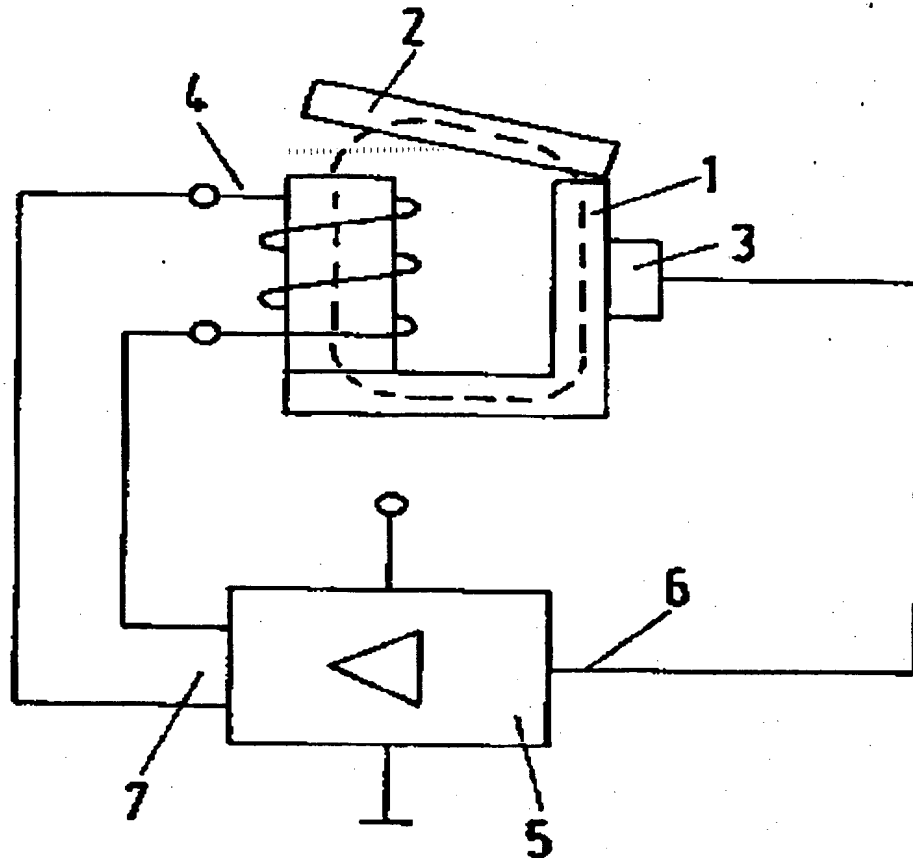
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Fig.1



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H1P PC P202
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(56) Documents cited

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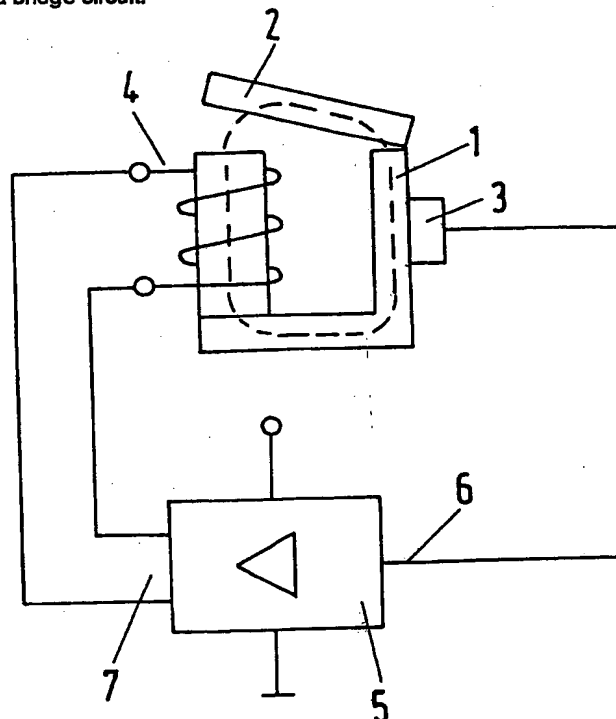
(58) Field of search

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(54) Detecting the operation of an electromagnetic actuator

(57) The actuator for a valve has an armature 2 which is displaced into a valve closure position when a coil 4 is energised. In order to reduce the electrical power loss and to increase the operational reliability of the actuator, a magnetic flux sensor 3 for detecting a variable proportional to the magnetic flux is connected to the core 1. The magnetic flux sensor 3 is connected to an electronic control device 5 in such a manner that the electrical power supplied to the coil 4 can be controlled by the detected variable proportional to the magnetic flux. The sensor may be a Hall effect device or a magnetic field variable resistor connected in a bridge circuit.

Fig.1



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Fig.1

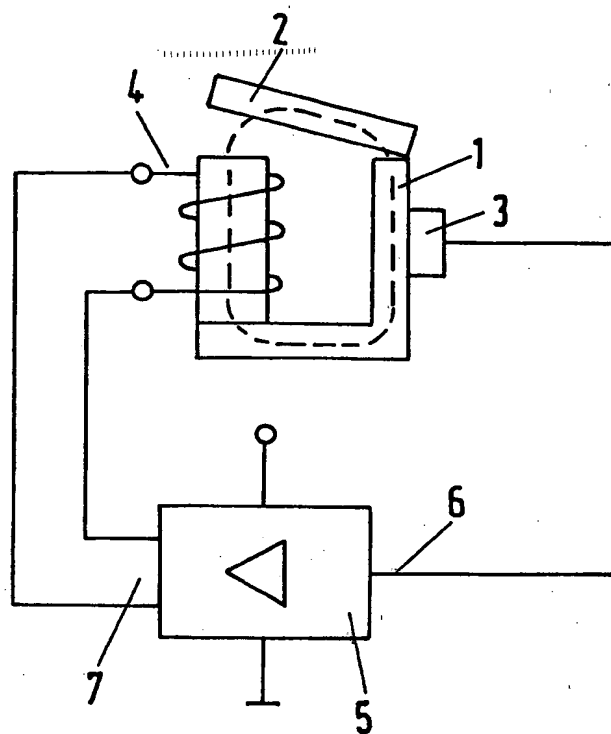
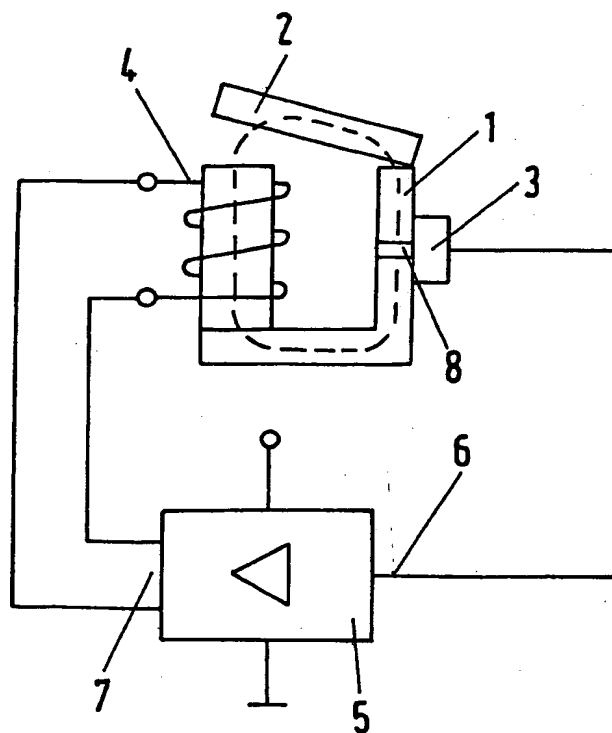


Fig.2



Electromagnetically actuated valve

The invention relates to an electromagnetic switching device for a valve, which device is actuated by means of a coil. Such devices typically comprise a multiple-part, segmentally movable magnetic core provided with a coil.

When an electric voltage is applied to the coil in devices of this kind coupled to a valve, the valve slide or other component coupled to the valve, is actuated and thus the valve is actuated. For example, valve discs are raised from or closed on valve seats. It is also known to detect the position of the valve slide in order to provide information on the state of actuation of the electromagnetic drive or of the valve itself. Many different designs are known for the electromagnetic "switching device" or "switch" of valves of this kind.

Electromagnetic switching devices typically comprise a generally two-part magnetic core provided with a coil. The magnetic core; i.e., the two magnetic core segments, consists of thin individual transformer sheets piled on top of one another to the thickness of the magnetic core. A laminated core of this kind reduces eddy-current losses. When an electric voltage is applied to the coil, the current generates a magnetic field in the magnetic core. This leads to the mutual attraction of the two magnetic core segments and to the formation of a closed magnetic circuit. The magnetic core

normally comprises a fixed part carrying the coil and what is referred to as a movable part or movable armature. When using a magnetic system of this kind, the armature is also connected many times to switching elements, with the formation of a relay.

An electromagnetic switching device is disclosed in German Patent Specification No. 26 14 926, in which a magnetic core of this kind actuated by a coil is in the form of a hinged armature magnetic core and is used in a switching relay. In this device, there is an air gap between the fixed magnetic core segment and the armature in the non-actuated state. As soon as an electric voltage or an electric current is applied to the coil, the generated magnetic forces close the magnetic circuit, and the armature is attracted to the fixed magnetic core. In order to release the armature from the fixed magnetic core when the voltage or current is disconnected, the armature in this example is connected to an appropriate spring.

The air gap in a magnetic system of the type just described produces high magnetic resistance in the magnetic circuit. A high magnetic voltage must be generated in order to achieve the magnetic force required for movement of the armature. This is achieved by means of a correspondingly high coil current determined by the coil wire resistance. Once the armature has executed its movement towards and into contact with the core, the air gap is closed. The magnetic circuit

resistance in this switched state is very low and the magnetic flux increases accordingly. The strength of the magnetic flux in the switched state is then far in excess of the level required to hold the armature in its closed position. The power thus supplied to the coil leads to undesired heating of the coil if the switched operating state is maintained for a long period of time. Consequently, the power loss of an electromagnetic switching device of this kind is very high. Although this is not important in the case of an individual relay, it increases in the case of a multiple arrangement of switching devices in a larger circuit arrangement.

An electromagnetic switching device is known from German Specification No. 15 40 507, in which an adjustable magnetic shunt is effected by what are referred to as flux concentrating pieces as a function of the path travelled by the armature. The flux concentrating pieces comprise slidably guided slides of non-magnetic material having openings distributed in the longitudinal direction, into which inserts of magnetisable material are introduced. These slides are displaced upon the movement of the magnetic armature in such a manner that the shunt becomes more or less effective according to the switching state. In this manner, the force requirement is adapted as a function of the armature path. In this case, there is no direct reduction of the electrical power supplied to the coil, principally resulting in the same disadvantages found in the prior art described hereinabove. When installing electromagnetic switching devices of this kind; e.g., in

moving or vibrating parts of a plant, there is a risk that the hinged armature will be raised for a short time as a result of mechanical vibrations and could for example, briefly release a closed electrical contact. In addition, contamination of the surfaces of the magnetic core lying on top of one another after closure of the air gap can result in chattering of the magnetic core segments and thus of the switched over electrical contacts. This can therefore lead to dangerous operating conditions according to the nature of the operating parts switched by devices of this kind. Moreover, a switching device of this kind is extremely ill-suited for use in valve actuation.

The present invention is directed at an electromagnetic switching device for a valve which operates with minimal electrical power loss while also achieving operational reliability with respect to the specific application in the valve or valves with which it is coupled. According to the invention, such a device comprises a magnetic core with an actuating coil and a movable part for connecting to a said valve; a magnetic flux sensor connected to the core for detecting a variable proportional to the magnetic flux in the core, the sensor being connected to an electronic control device such that the electrical power supplied to the coil and thus movement of the movable part is controllable in accordance with the detected variable proportional to the magnetic flux.

The invention offers a number of advantages over known valve devices. As the magnetic resistance and thus the magnetic flux in the magnetic circuit are dependent upon the size of the air gap, the latter can be influenced via the magnetic flux sensor by readjustment of the power supplied to the coil. When the magnetic circuit is open; i.e., distanced by the air gap, correspondingly high electrical power is supplied to the coil to close the magnetic circuit. If the magnetic circuit is then closed, the magnetic resistance in the magnetic circuit then falls and the magnetic flux increases accordingly, and this can be recorded by the magnetic flux sensor. When using a Hall-effect element as the magnetic flux sensor, the Hall voltage generated in this manner is a variable proportional to the magnetic flux. This Hall voltage is connected as an input variable to an electronic control device and continuously influences the electrical power or voltage supplied to the coil as a function of the level of the magnetic flux. This means that after closure of the magnetic circuit the electrical power supplied to the coil is reduced in an advantageously simple manner to the level required to keep the magnetic circuit closed. The power loss is thus considerably reduced and the operating temperature of the coil or of the entire electromagnetic switching device is also reduced. Even if the magnetic circuit is subject to chattering for whatever reason, corresponding compensation is effected by this control device, so that the magnetic circuit always remains closed in the actuated state. If the armature is raised unintentionally, the magnetic flux sensor records a

drop in the magnetic flux and thus opens the electronic control device in such a manner that the coil is supplied with a higher electric voltage for a short period of time until the armature or the magnetic circuit is closed again. In addition to the reduction of the power loss and the operating temperature, this also leads to increased operational reliability, particularly when using switching elements in moving parts of plants.

In addition to the possibility of using a Hall-effect element as the magnetic flux sensor, it is possible for the magnetic flux sensor to be in the form of a resistance bridge that can be provided with an electrical resistor sensitive to magnetic fields. The resistor sensitive to magnetic fields is directly connected to the magnetic core and is connected via the other resistors not sensitive to magnetic fields to a resistance bridge. When using the resistor, the voltage ratios in the resistance bridge vary as a result of a variation in the magnetic flux, which can then itself be used as a variable proportional to the magnetic flux at the input of the control device.

In its normal use, an electromagnetic device according to the invention acts as the actuating element of a valve. Actuation of a valve plunger or valve slide is effected via the multiple-part magnetic core. The movable part of the core can be frictionally connected to the valve slide. An electromagnetic element of this kind in a valve can thus

control liquid or gaseous media or hydraulic media. The reliable switched states of the magnetic core also mean, as a result of the frictional connection to the valve slide, that switched states of the valve can be maintained in a safe and reliable manner. However, all embodiments of the invention offer the particular advantage of a reduction of the power used in the switched state.

An operational amplifier is preferred as the electronic control device in switching devices according to the invention. This offers the advantage that the operational amplifier delivers a large variable voltage range at the output, so that it is possible to control coils or electromagnets having different power consumption rates via the same operational amplifier.

The invention will now be described by way of example, and with reference to the accompanying drawing, in which:

Figure 1 shows an electromagnetic switching device with a hinged armature magnetic core; and

Figure 2 shows an electromagnetic switching device with a Hall probe in the additional air gap.

Figure 1 shows the arrangement of an electromagnetic switching device comprising a coil and a magnetic core in the form of a hinged armature magnetic core. A magnetic flux

sensor 3 is connected to the magnetic core and detects the magnetic flux within the magnetic circuit via a variable proportional to the magnetic flux. The fixed part of the magnetic core consists of a U-shaped magnetic core 1, a hinged armature 2 being hinged on to the open end thereof. In the state shown there, the magnetic circuit is open; i.e., there is an air gap between the hinged armature 2 and the fixed magnetic core 1. The magnetic flux sensor may consist of a Hall-effect element which delivers a Hall voltage proportional to the magnetic flux. A further possible embodiment consists in designing the magnetic flux sensor as a resistor sensitive to magnetic fields and connected to a resistance bridge. Both possible embodiments essentially record the magnetic leakage flux around the magnetic core and are arranged externally on the magnetic core. A further possible embodiment using a Hall-effect element is described hereinbelow with reference to Figure 2. The variable proportional to the magnetic flux delivered by the magnetic flux sensor 3 is supplied as an input variable 6 to an operational amplifier. This electronic control device 5 in the form of an operational amplifier then delivers an output voltage proportional to the variable proportional to the magnetic flux at the output 7, this output voltage being supplied to the coil 4 of the electromagnetic switching device. If the magnetic flux within the magnetic core then falls; i.e., if the armature is raised from the other magnetic core, the coil voltage of the operational amplifier is ultimately increased, for long enough or to such an extent that the armature is attracted

once again and the magnetic circuit is closed once again. The simplicity of the embodiment of the magnetic flux sensor in the form of a resistor sensitive to magnetic fields within a resistance bridge connected thereto offers constructional advantages. This resistor sensitive to magnetic fields, which is directly connected to the magnetic core, does not record the magnetic field guided into the magnetic core, but the leakage field existing around the magnetic core. However, as this is also a measure of the magnetic flux guided into the magnetic core, this possibility can be used in an advantageous and effective manner. A variation of the magnetic flux within the magnetic circuit also results in a variation of the leakage flux, so that this leakage field recording also delivers a variable proportional to the magnetic flux. The resistor sensitive to magnetic fields is connected to what is referred to as a resistance bridge. The resistance bridge can be adapted in such a manner that, in the normal state; i.e., the closed state, of the magnetic circuit, the resistance ratios in the resistance bridge are symmetrical. Raising the hinged armature would result in a resistance variation in the resistor sensitive to magnetic fields, which would mean that the resistance ratios in the resistance bridge would become asymmetrical. This asymmetry generates voltage differences in the resistance bridge which then ultimately deliver the variable proportional to the magnetic flux and fed into the control device to control the coil voltage or coil current. In this arrangement, it is particularly advantageous that the magnetic flux sensor can simply be applied externally to the

magnetic core.

Figure 2 shows the use of a Hall element as a magnetic flux sensor with a further possible arrangement in the magnetic circuit. As a Hall-effect element generally consists of a thin foil which is supposed to be traversed directly in the case of optimum use of the field lines of the magnetic field, it is provided in this case to break the magnetic circuit at a defined point by means of the smallest possible air gap 8, into which the Hall-effect element is inserted. The magnetic field lines are used even more efficiently in this manner. This additional air gap naturally produces further magnetic resistance within the magnetic circuit. However, this must be tolerated when using a Hall-effect element which can have a very thin design. A variation of the magnetic flux within the magnetic circuit results in a variation of the Hall voltage, which for its part can then be supplied once again to the input 6 of the control device 5 as a variable proportional to the magnetic flux.

If the magnetic circuit is closed after voltage is applied to the coil, the coil voltage and thus the coil current is reduced accordingly to the level required to keep the magnetic circuit closed. The power loss is thus adjusted to almost zero and moreover there is permanent monitoring of the switching state of the electromagnetic switching device. Disturbance, i.e., unintentional opening, is thus always counteracted by controlling the coil voltage or coil current.

In general, the operational reliability of a device of the invention is considerably increased, with the secondary effect that the working or operating temperature is also reduced.

Claims

1. An electromagnetic switching device for valves, comprising a magnetic core with an actuating coil and a movable part for connection to a said valve; a magnetic flux sensor connected to the core for detecting a variable proportional to the magnetic flux in the core, the sensor being connected to an electronic control device such that the electrical power supplied to the coil and thus movement of the movable part is controllable in accordance with the detected variable proportional to the magnetic flux.
2. An electromagnetic switching device according to Claim 1 wherein the electronic control device comprises an operational amplifier which is connected at the input to the magnetic flux sensor and at the output to the coil.
3. An electromagnetic switching device according to Claim 1 or Claim 2 wherein the magnetic flux sensor comprises a Hall-effect element.
4. An electromagnetic switching device according to Claim 1 or Claim 2 wherein the magnetic flux sensor comprises a resistance bridge provided with an electrical resistor sensitive to magnetic fields.
5. An electromagnetic switching device substantially as herein described with reference to the accompanying drawing.
6. An electromagnetically actuated valve including a device according to any preceding Claim.

Patents Act 1977
Examiner's report to the Comptroller under
Section 17 (The Search Report)

Application number

GB 9218499.3

Relevant Technical fields

(i) UK Cl (Edition K/L) H1P (PC)

(ii) Int Cl (Edition 5) H01F

Databases (see over)

(i) UK Patent Office

(ii)

Search Examiner

C D STONE

Date of Search

21 OCTOBER 1992

Documents considered relevant following a search in respect of claims **ALL**

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB A 2183098 (WESTINGHOUSE)	1, 3
X	GB A 2112213 (GENERAL ELECTRIC)	1, 3
X	GB A 2041573 (LUCAS)	1
X	GB 1594578 (HART)	1, 3
X	GB 1324445 (VOITH GETRIEBE)	1-4
X	EP A1 0209287 (SYNEKTRON)	1, 3

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